Offshore Sailboat Attributes:




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Paul H. Miller, D.Eng. P.E.
Professor of Naval Architecture
United States Naval Academy

Seaworthiness

"To be seaworthy, the vessel must be able to defend itself against the incursion and perils of the sea…"

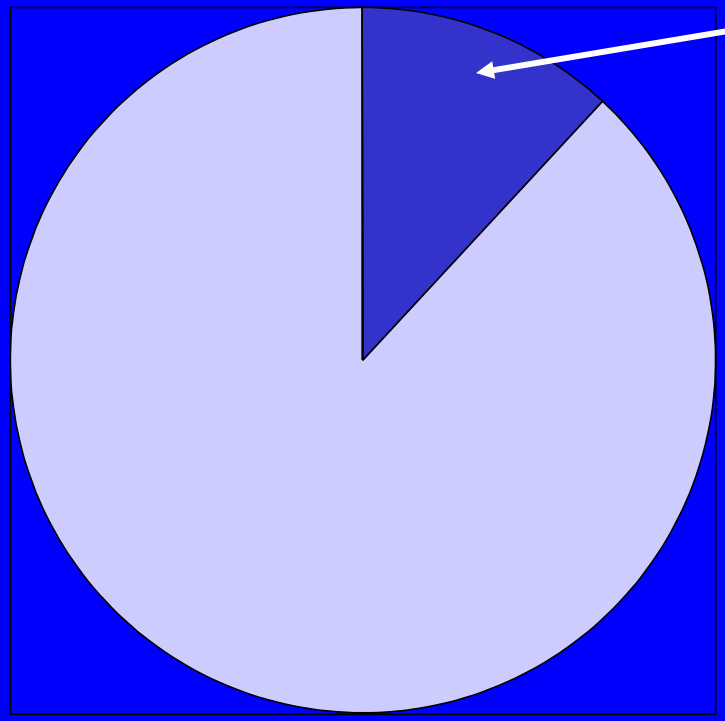
From "Seaworthiness: The Forgotten Factor" by C.A. Marchaj

A classic example of a seaworthy design.
Low center of gravity, versatile rig, narrow beam

But perhaps a bit impractical?

Question: What percentage of recreational marine accidents are related to design, construction or equipment?

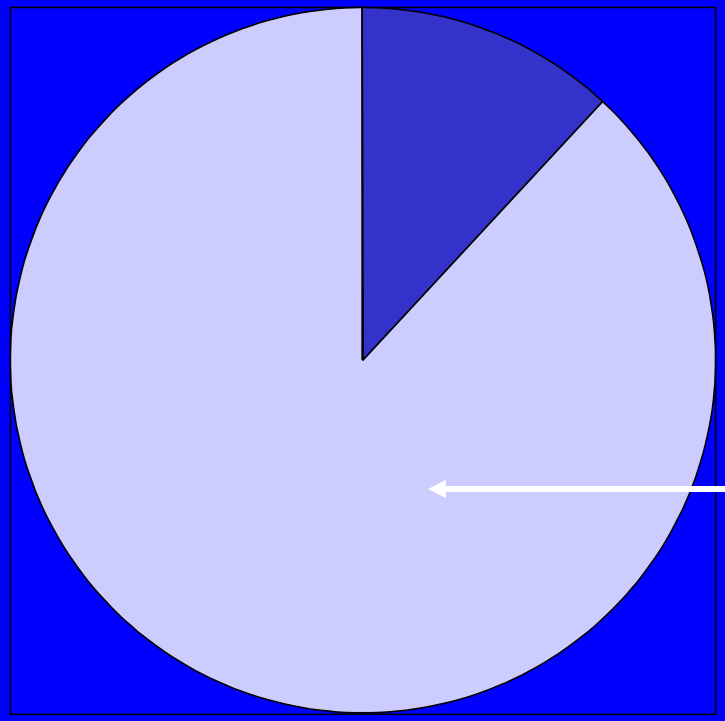
1998 USCG Boating Statistics



11% Design, Construction and Equipment Issues

Human Error is the biggest problem!

1998 USCG Boating Statistics



89% Owner and Operator Mistakes (Training, Attitude, Preparation, Weather, Fatigue, etc)

“To finish first, first you have to finish.”

The keel is still there, but the mast is not!

How h Risk Will You Take?
"Ho ucky Do You Feel?!"

s your acceptable level?

r, is this?

Risk

Preparation + Training + Cost + Attitude + Routin

For your level of acceptable risk…

If your level of training and experience is minimal, then:

- Get more **training**/practice (go to sailing camp!)
- Adopt a more **conservative attitude** to routing
- Increase your boat **preparation**/equipment
- Choose a more **co** n!

Some great voyages have been made in spite of the boat design and equipment!

Design Attributes:
The Basic Rules to Reduce Risk
(Sail or Power)

1. Watertight integrity: Keep Water Out!
2. Stability: Keep the Vessel Upright!
3. Maintain Steering and Weatherliness
4. Simplicity

These requirements often conflict with other goals, such as speed vs. comfort vs. cost vs. draft vs. ...

Watertight Integrity (In Brief)

1. Hatches/boards
2. Port lights (storm shutters)
3. Vents/Dorades
4. Through hulls
5. Mast

1. Rudder shaft
2. Control lines
3. Prop shaft
4. Locker covers
5. Charlie Nobles
6. Construction (ABS Rules)

Hint: Give your boat a good shower

Watertight is good, airtight is not

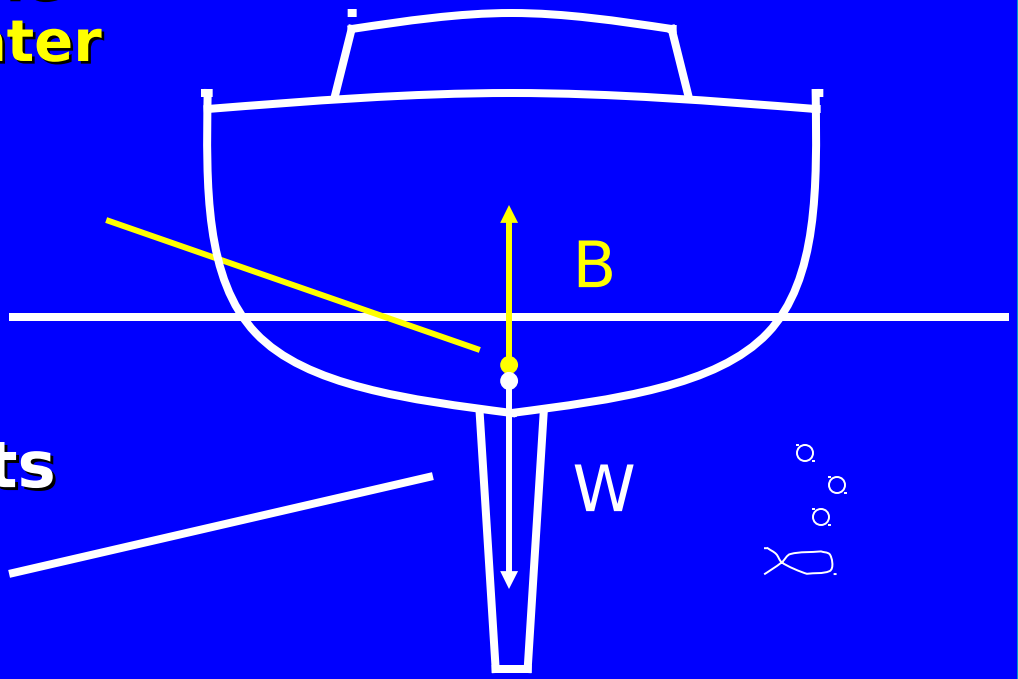
Lessons Learned and Relearned

1. The 1979 Fastnet pointed out the dangers of wide beam and light displacement.
2. The Rating Rules were changed to encourage stability. (’98 Sydney-Hobart)
3. Boats became more stable at large heel angles.
4. Today, many “cruising boats” have wider beams, lighter displacements and higher CG’s than pre-1979 boats…

Static (not moving) Stability

- **Buoyancy Force acts upward through the center of underwater volume (Center of Buoyancy)**

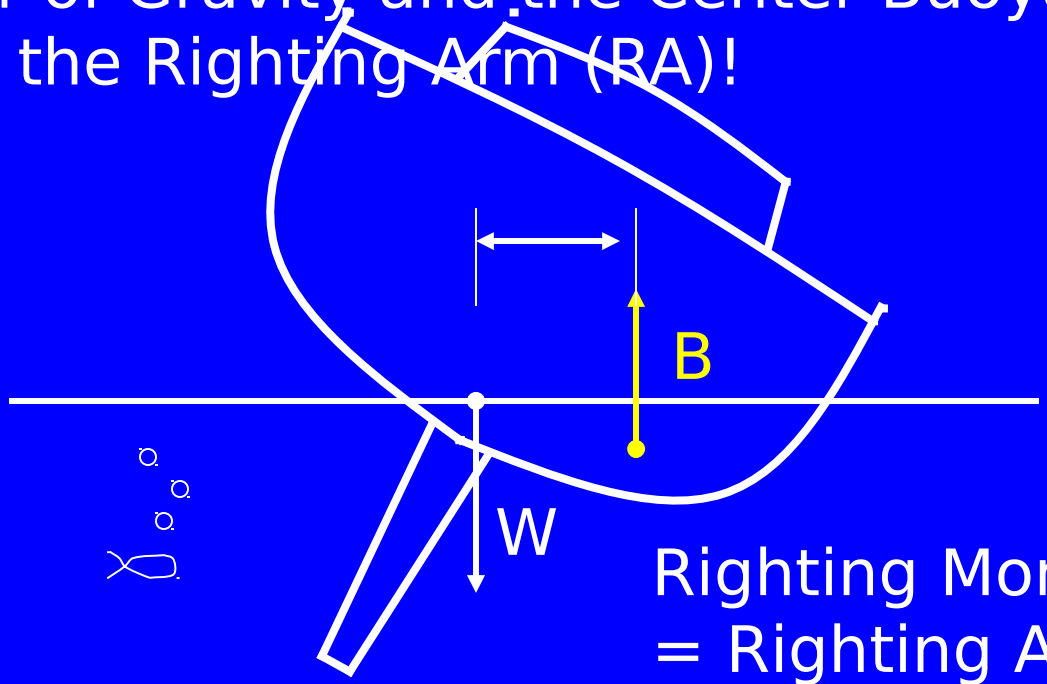
- **Weight Force acts downward through the Center of Gravity**



Sum of the Forces equals Zero

Static Stability When Heeled

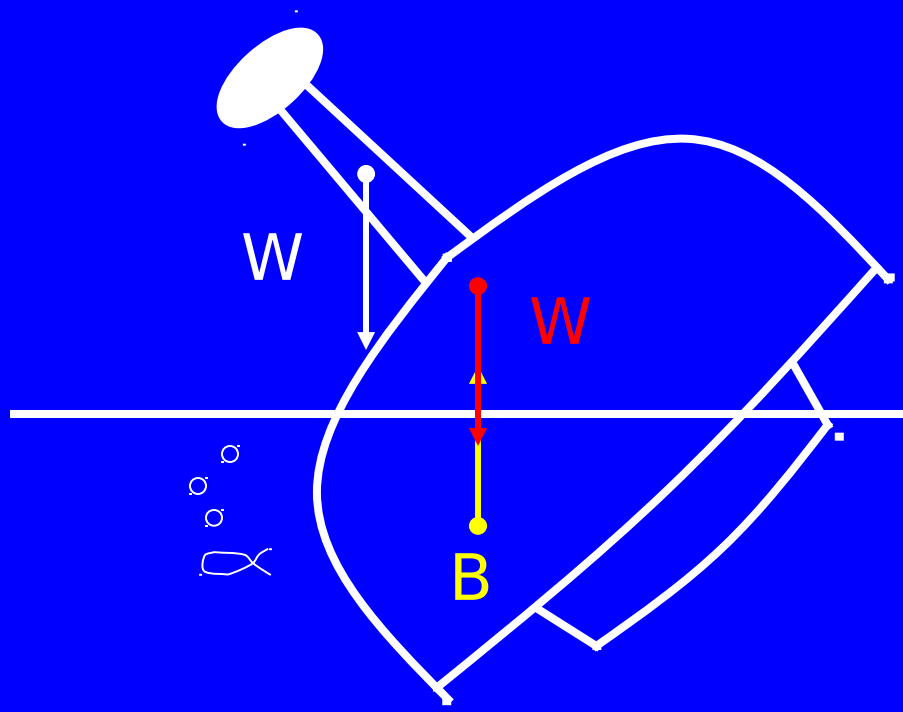
This lever, the horizontal distance between the Center of Gravity and the Center Buoyancy is called the Righting Arm (RA)!



"Give me a <u>lever</u> and I will move the earth!" (or at least right a boat!)

Righting Moment = Righting Arm x Boat Weight = "Stability"

Static Stability When Really Heeled!

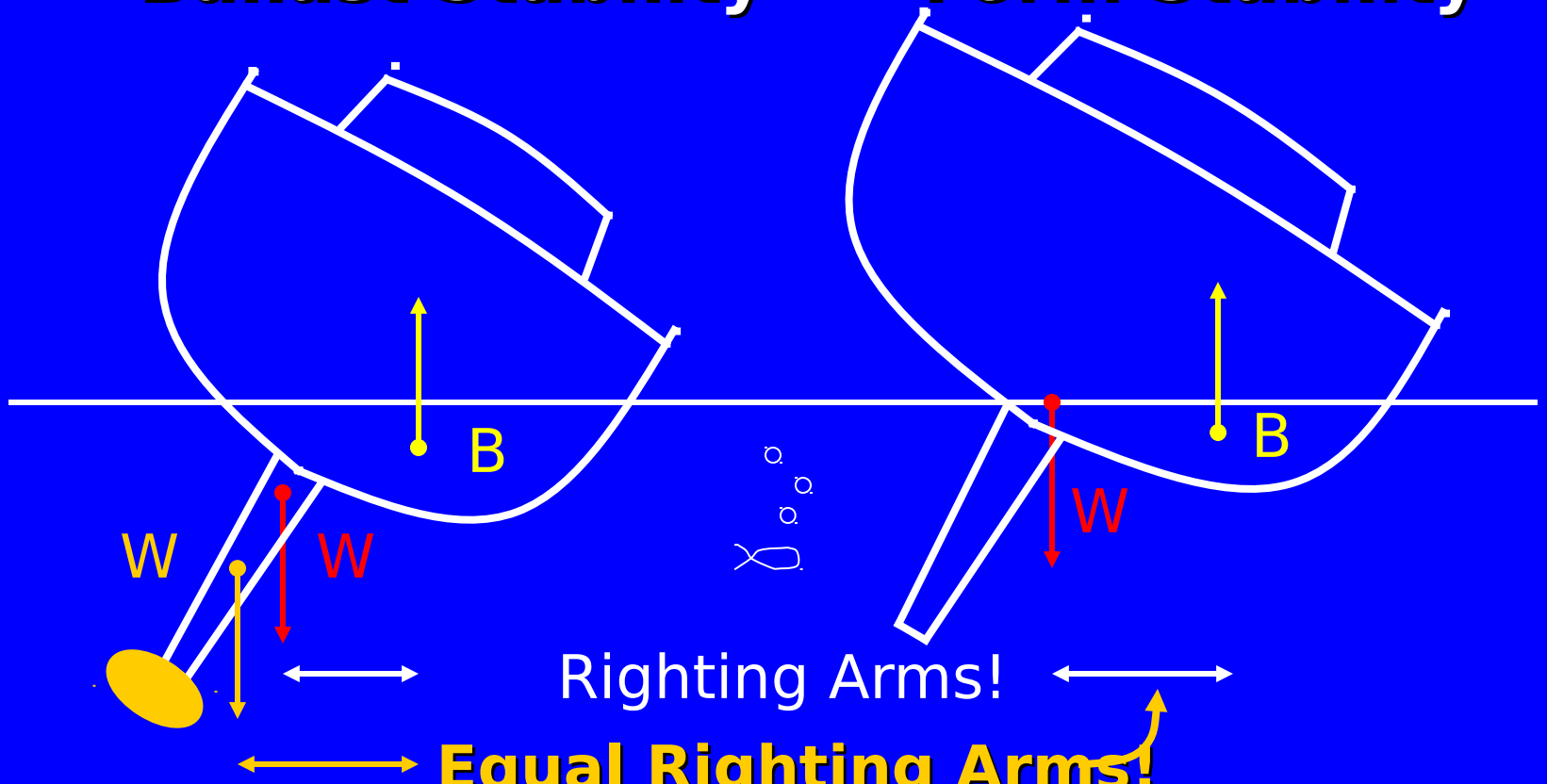


Limit of Positive Stability "LPS" is when the two vectors are colinear.

Moral of this story: A Low Center of Gravity is Nice!

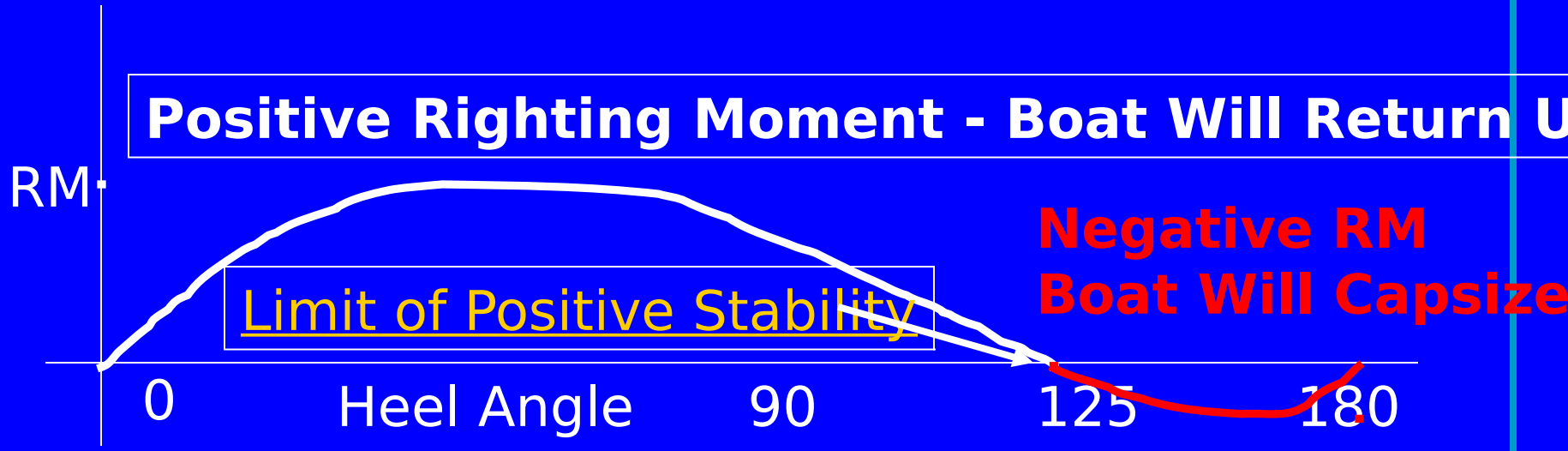
Static Stability - Beam Effects

"Ballast Stability" "Form Stability"



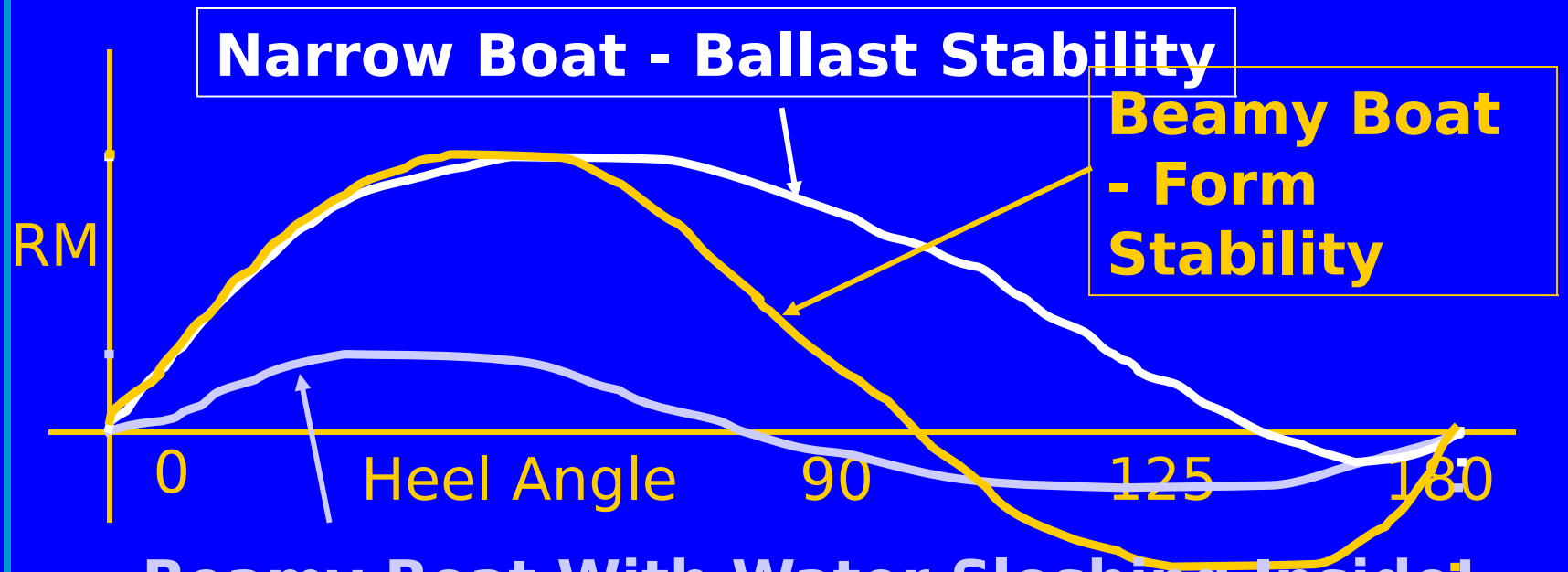
Static Stability Lessons

1. **Beam Provides Stability at Small Angles (<40°)**
2. **A Low Center of Gravity <u>Always</u> Provides Stability**
3. **For the <u>Same</u> Initial Stability a Narrow Boat Needs a Lower CG (More Keel Ballast-More Weight?).**



Righting Moment Curves

Positive area under the curve = work to capsize!



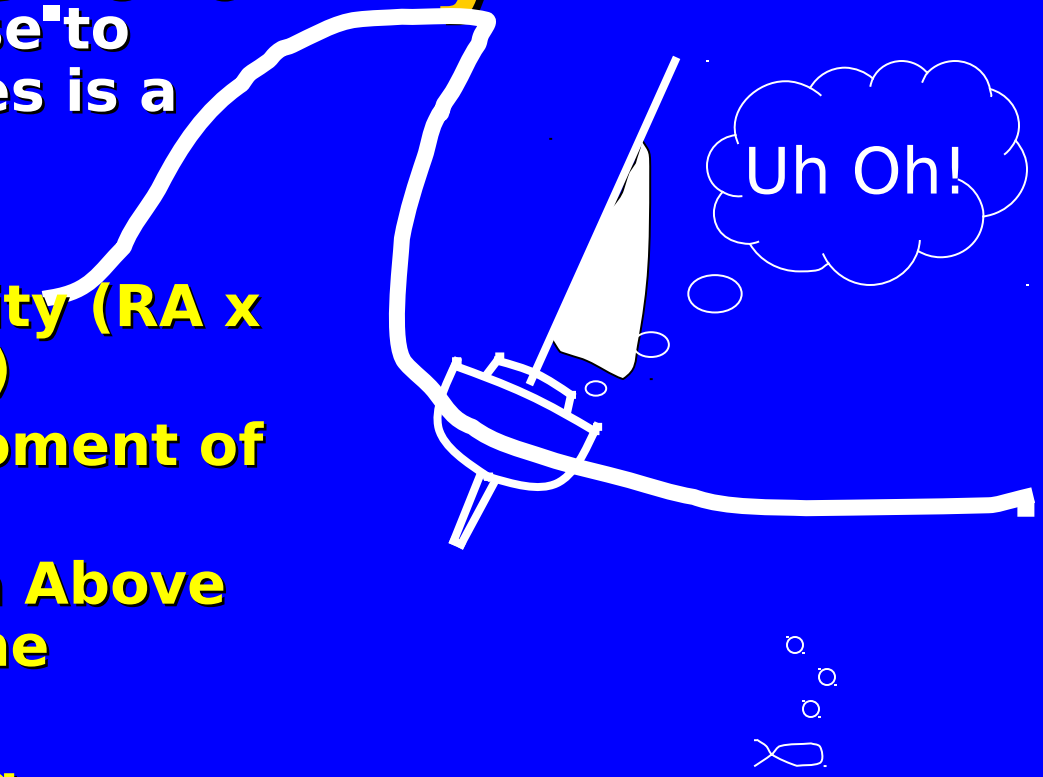
Beamy Boat With Water Sloshing Inside!

Negative area under the curve = work to re-righ

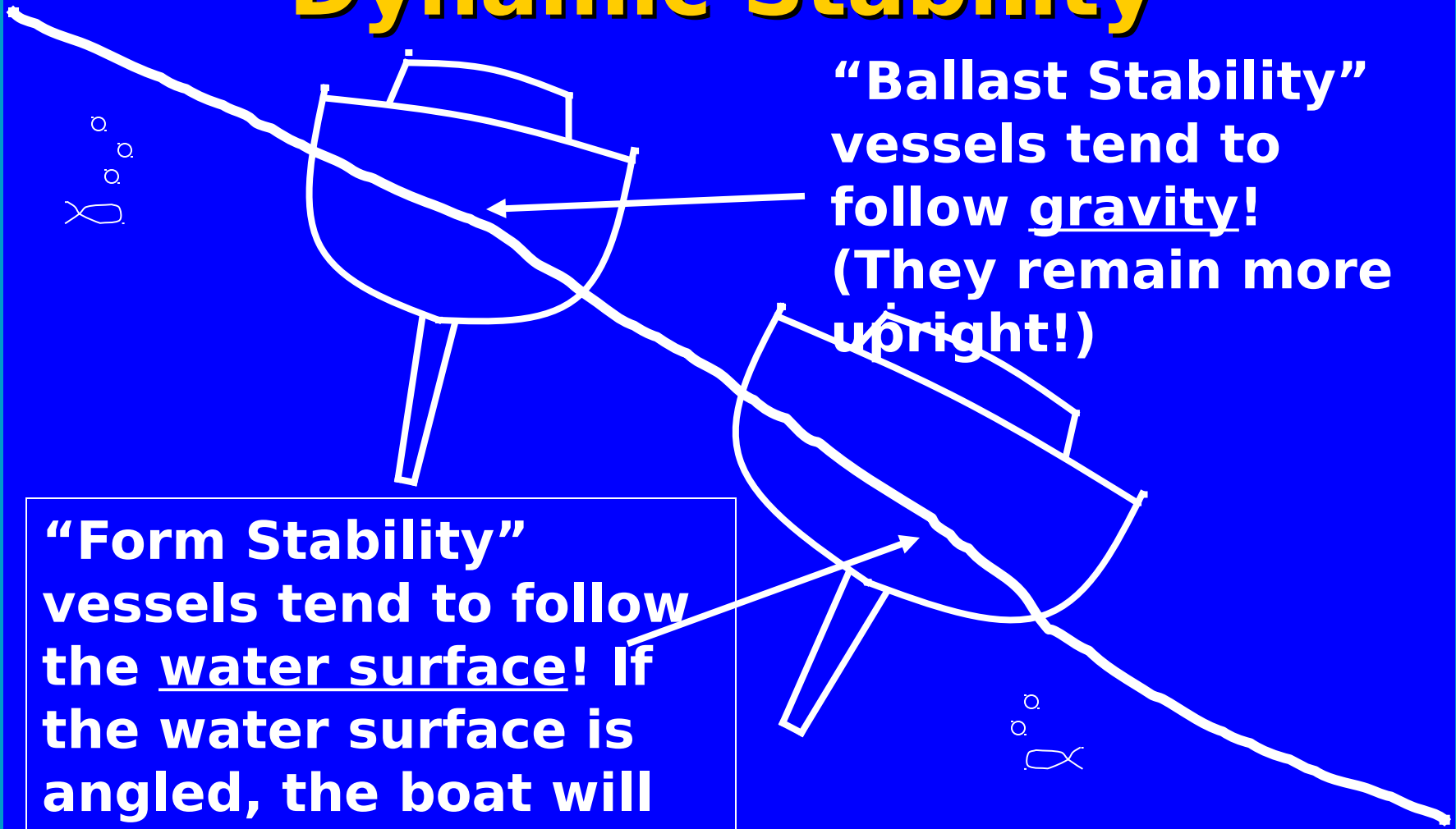
Dynamic (Moving) Stability

A Vessel's Response to Wind and Waves is a function of:

- **Sails Set**
- **Static Stability (RA x Boat Weight)**
- **Roll Mass Moment of Inertia**
- **Surface Area Above and Below the Surface**
- **Roll Damping**
- **Luck!**



Dynamic Stability



“Ballast Stability” vessels tend to follow gravity! (They remain more upright!)

“Form Stability” vessels tend to follow the water surface! If the water surface is angled, the boat will be too!

Best Approach to Evaluating Capsize Resistance

- **A large area under the Positive Righting Moment Curve (and small negative area!)**
  - **High Limit of Positive Stability**
  - **Large Displacement**
  - **Low Center of Gravity**
  - ***Possibly available from the designer***

Less Rigorous But Easier Evaluators

1. LPS >125 for cruisers (may be available from US Sailing for a sistership, or ask a yacht designer)
2. Ballast/Disp>40% and no shoal keels!

3. Capsize Screening Formula (a ***rough*** guide of form vs. ballast sta

$$\frac{Beam}{\left(\frac{BoatWeight(lbs)}{64}\right)^{1/3}} \leq 2$$

What happened to CG and length?

Screening Factor Examples

Hunter 28

LOA = 28’
BEAM = 10.5’
DISP = 7400 LB
CSF = 2.15

Tartan 28

LOA = 28’3”
BEAM = 9.8’
DISP = 7450 LB
CSF = 2.0

Hallberg Rassy 29

LOA = 29’3”
BEAM = 9.33’
DISP = 8360 LB
CSF = 1.821

More Screening Factor Examples

Cape Dory 28

LOA = 28’2”
BEAM = 8.9’
DISP = 9000 LB
CSF = 1.7

Rozinante

LOA = 28’
BEAM = 6.25’
DISP = 7100 LB
CSF = 1.3 !

Remember that the CSF equation does not include some important terms! (CG, damping, MMI, etc.

Is Bigger Always Better?

1. **The Static Stability Curve, Damping and Mass Moment of Inertia terms do not have "length" factors.**
2. **Center of Gravity, weight, draft, surface area, and beam are more important than length!**

Bottom Line

An increase in length leads to greater comfort, possibly higher stability, higher loads and lower

Is “Fast” Unsafe?
Can a performance boat be safe?

Things to consider:

1. **Outrun weather**
2. **Crew weight! (wide beam)**
3. **Your Approach**
4. **Weatherliness (upwind ability)**

So the answer is “maybe”!

Rudder and Keel Area

Can You Climb Off a Lee Shore?

1. Stability and appendage area are related
2. At lower speeds you need more area
3. Rough guide:
   - Keel Area > 3.5% of Sail Area
   - Rudder Area > 1.5% of Sail Area

Three Quotes To Remember

"A Modern Sailboat…

1. cannot be too stable."
2. can be either too weak or too strong."
3. can have rudders and keels that are too small and are too shoal."

Some “Lower Risk” Offshore Designs (for a couple)

Flicka 20
CSF=1.8
Great for newlyweds!

Frances 26
CSF=1.7
Enough for 2?

Pearson 30
CSF=1.9
Value Cruiser?

More “Lower Risk” Offshore Designs (for a couple)

Crealock 34
CSF=1.7
Enough for 2?

Alerion Express 38
CSF=1.9
My dream boat?

Cal 40
CSF=1.8
A great all-round design

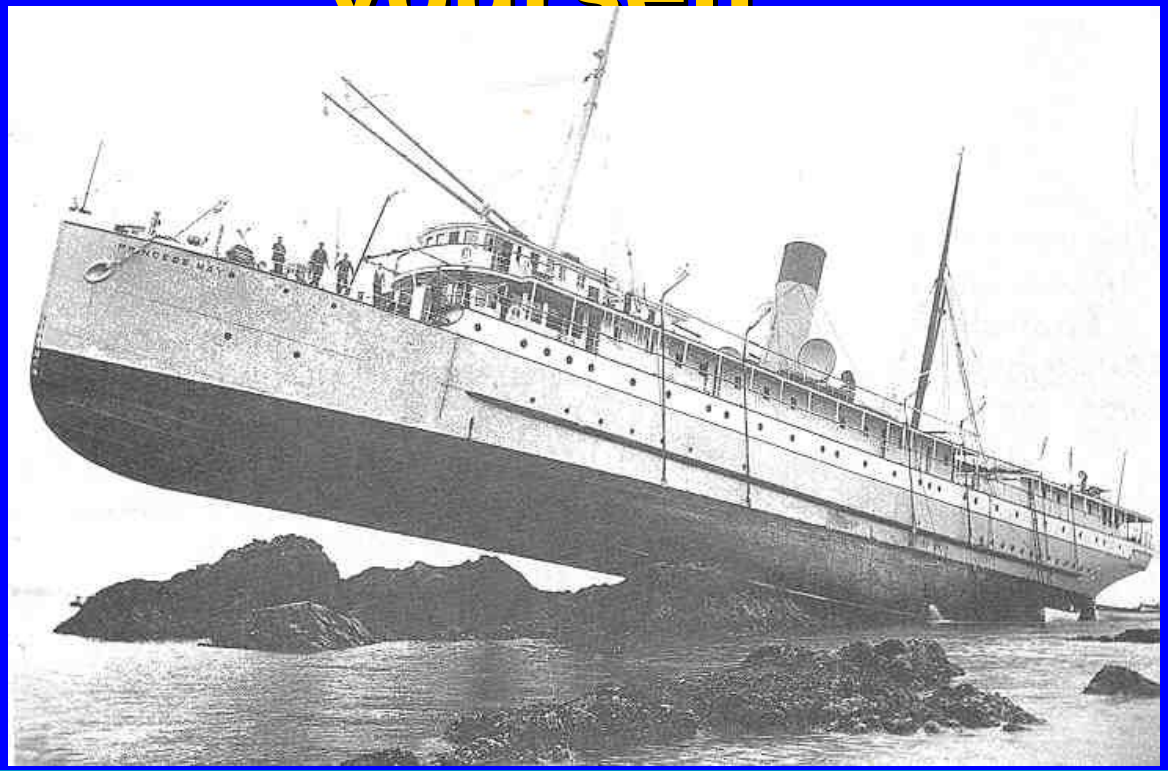
A boat, although a good design, is only as seaworthy as the condition it is in and the skill of the crew that sails it!

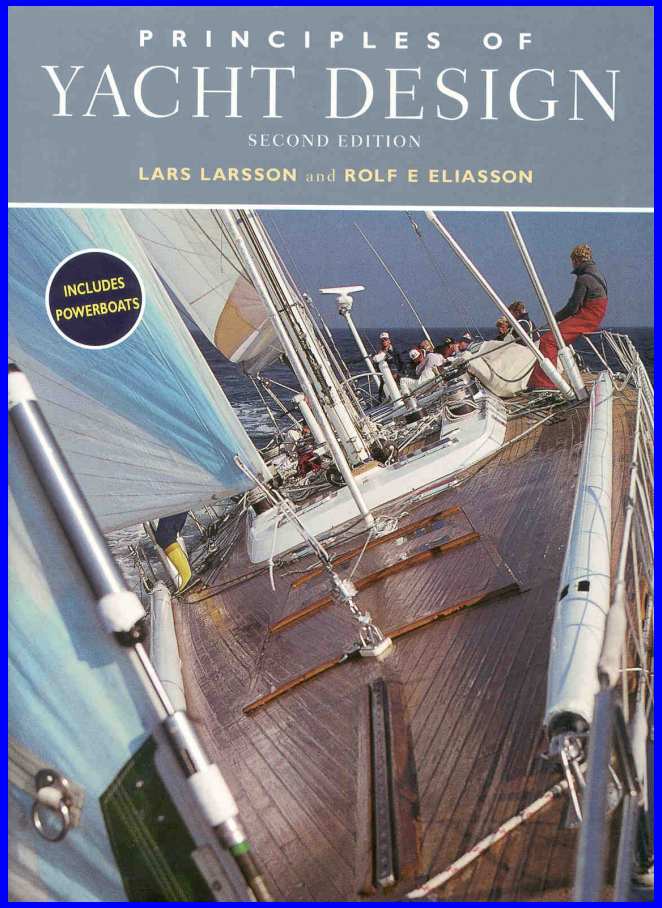
Attributes that increase risk

1. Shoal draft keels (too high a CG, reduced weatherliness)
2. High windage rigging (steps, main furlers)
3. Boats that rely on crew weight for stability

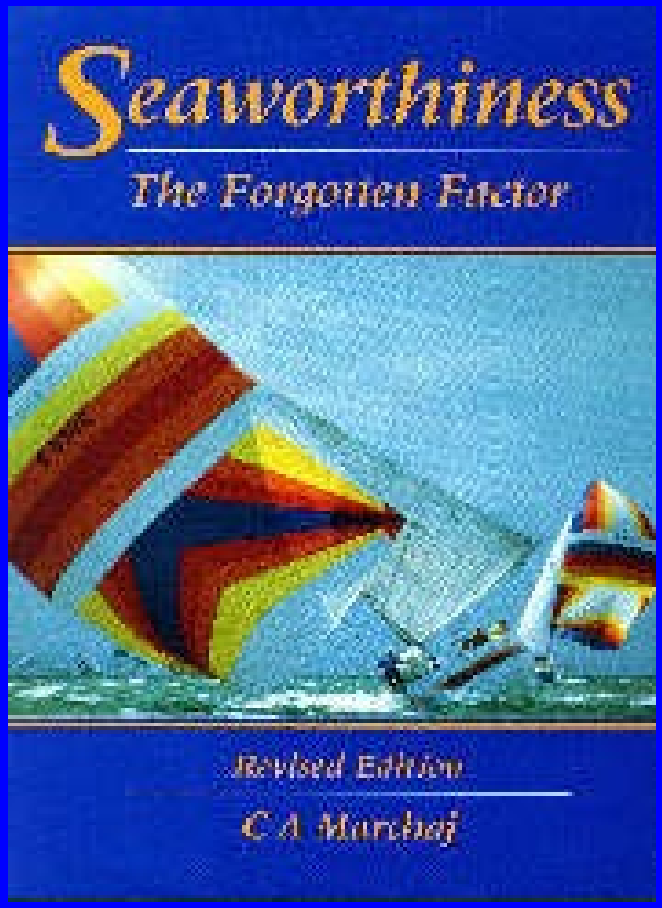
1. Small keels and rudders (lack of control at low speed)
2. Racing rigs
3. Flat bottoms
4. Large windows

“Learn from the mistakes of others, because you won’t live long enough to make them all yourself”





"Principles of Yacht Design"
Larsson and Eliasson

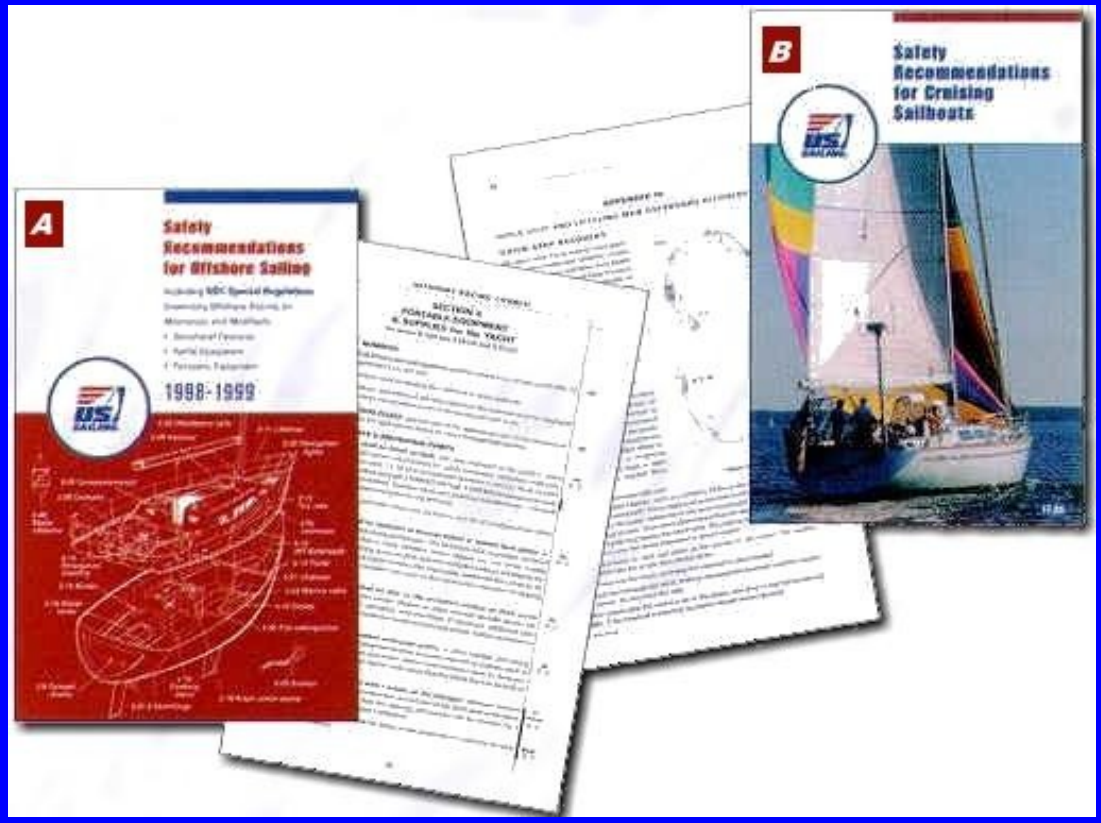


"Seaworthiness: The Forgotten Factor"
C. A. Marchaj

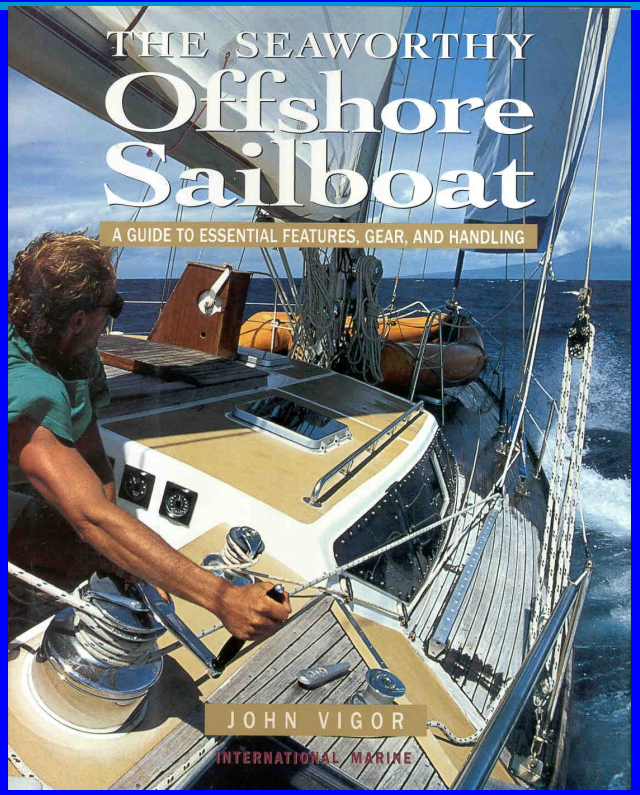
From US SAILING:
Equipment Guides
Safety Recommendations for Offshore Sailing

or

Safety Recommendations for Cruising Sailboats

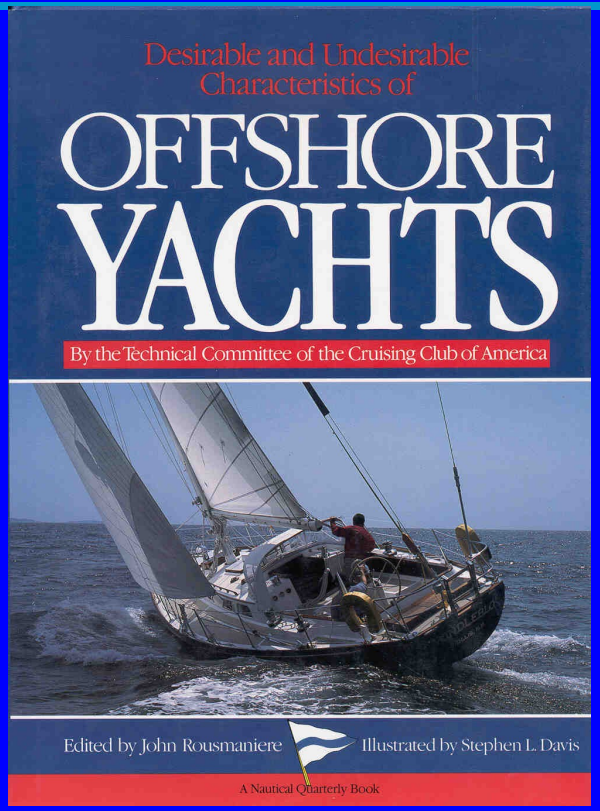


And, “Safety From Capsizing; Final Report”



"The Seaworthy Offshore Sailboat"

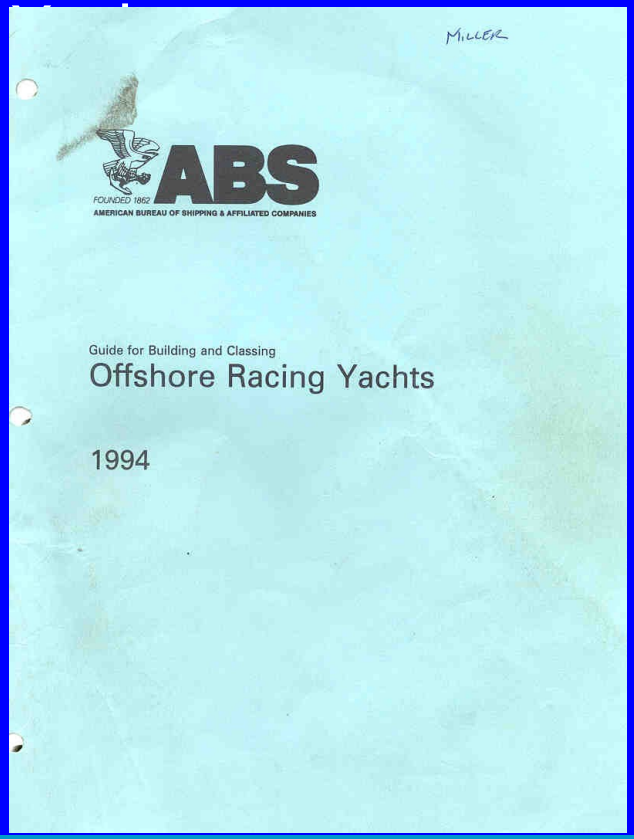
John Vigor



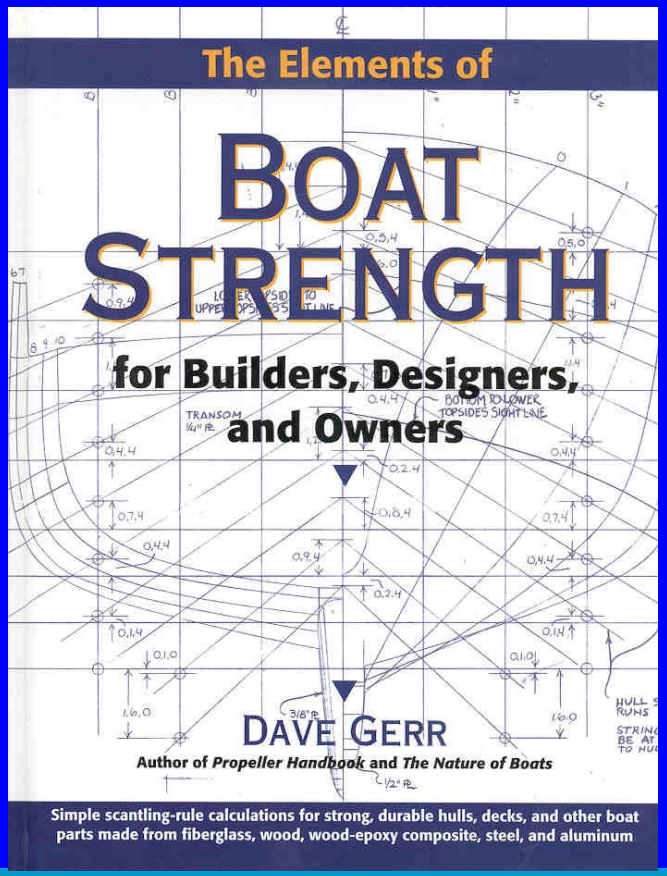
"Desirable and Undesirable Characteristics of Offshore Yachts"

by the CCA

American Bureau of Shipping Guide for Building and Classing Offshore Racing



The Elements of Boat Strength by Dave Gerr




One final thought:
Buy the smallest boat you can afford...
And go have fun!